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A modular approach to designing satellite simulations

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***Abstract* — Iterative approach to system design is used in the most modern satellite simulation systems. Although this approach is efficient, it is not scalable. A solution to this problem could be a modular approach to designing satellite simulations systems, which relies on isolated modules simulating different characteristics of the models and feed them into a more complex dynamic model.**

***Index Terms* — modular, system design, simulation, satellite.**

I. INTRODUCTION

Most modern satellite simulation systems use an iterative approach to system design, i.e. the simulation data (magnetic field model, gravitational model, etc.) are fed directly into the modules that simulate the behavior of specific subsystems [1]. For instance, the data from magnetic field model has a noise component added to it and is sent directly to the magnetometers. The operating system module then processes the data obtained by the magnetometer and acts correspondingly to the obtained measurements via a magnetometer or any other actuator module.

This kind of approach, although efficient, is not scalable. It does not allow precise testing procedures (for instance, changing a magnetometer and a magnetorquer with different models having different characteristics). Also, if the team decides to test a different actuator or sensor, additional models have to be provided and the module that simulates the operating system has to be revised in order to parse the data from the new model sent by the new sensor and be able to send this data to the actuator. This restricts experimentation with different kinds of hardware on the simulator, which is a key role of the simulation system. After all, it has to provide the engineers with results that would aid the decision making processes during the design of the satellite itself and its mission.

That is the main reason why we propose a different kind of modular approach to design the simulation systems.

II. APPROACH CONSIDERATIONS

Our solution heavily relies on isolated modules which simulate different characteristics of the models and feed them into a more complex dynamic model. The aim of this dynamic model is to be as complete as possible and independent of the number of the models that form it, the only thing it heavily depends on is the orbit description. For instance, the team chooses to integrate the Sun Vector model, the Gravitational model and the Magnetic field model into the simulation process. That is achieved by using the organization shown in fig. 1.

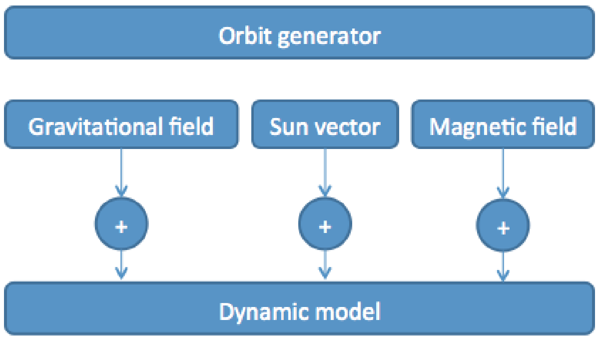

Fig. 1 – An example of a dynamic model.

The model data are sent with the corresponding perturbations and precision errors which are independent of the measuring devices, e.g. a magnetic field model using IGRF 2010 as its basis will have an error of 5nT [2].

The dynamic model will therefore encompass all the elements participating in the motion of the satellite with their respective measurement errors. All the models have to be stored in a database, which will describe the types, measurement techniques and their peculiarities (e.g. for a gravitational field, the order of the spherical harmonics taken into consideration, the function which is able to model the field from these spherical harmonics as well as their values). This database is designed in order to fill the most common models and one is able to build such a model that would contain both the star, magnetic, gravitational, aerodynamic, sun, navigational satellites and the horizon models.

Because the dynamic model contains all of the data related to the motion of the satellite and the environment, it is absolutely independent on the actuators or sensors. That is, if the team decides to add a specific type of a magnetometer, they would have to design a module that takes the data from the dynamic model by querying the database. From this point of view, testing the sensors and filtering the signals is a breeze.

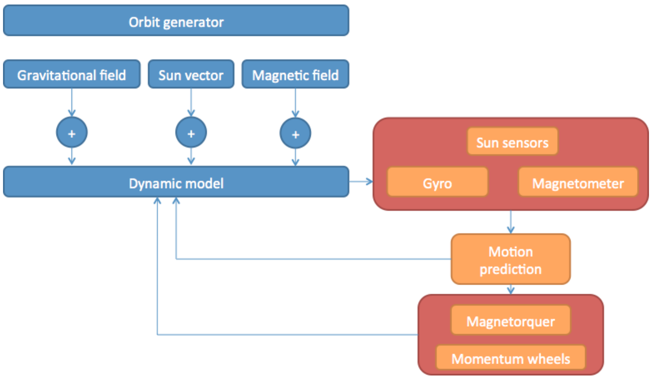

Fig. 2 – An example of a complete system.

However, in order for the system to be realistic, a prediction module and an operating system have to be integrated in the dynamic model. The dynamic model will therefore not only contain the "real" orbital data, but also the "measured" ones, because the actuators will not be able to access the real orbital model [3]. This approach of not isolating the measured and the actual motions of the satellite will allow for the same querying mechanism to be used on the actuators, i.e. since the dynamic model contains the magnetic field we can choose whether to add magnetometers as sensors even if we plan to stabilize the satellite using a mode of magnetic actuation.

This would mean that the actuators, although being independent on the sensors, will actually modify the real dynamic model, with the measured dynamic model being provided by the sensor modules. For instance, a complete system would be organized as in figure 2.

III. CONCLUSIONS

We are planning to expand this approach not only to satellites, but to other kinds of spacecrafts, which might require a more universal approach to space system simulation. However, the provided system has the flexibility of allowing us to test different kinds of actuators or sensors with ease.

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